BULLETIN

OF THE

Society for the Promotion of Engineering Education

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EDITORIALS.

The Second Volume of the Bulletin.—The activities of the Society are reflected in last year's BULLETIN, which contains 594 pages of reading matter, about one half of which does not form a part of the *Proceedings*. Bound up it makes a book two inches thick inside the covers. As the BULLETIN is now a permanent feature, the Publication Committee has prepared a title page and complete index to the volume, and this will be sent to any subscriber on request. A study of this index indicates the value of the contents of the BULLETIN as a record

of the year's progress in technical education. The Committee endeavored to record every event of note such as the holding of conventions where educational matters were touched upon, the addition of new buildings and important apparatus to the equipment of educational institutions, the installation of new officers of administration, etc. Special effort was made to describe and illustrate the construction of new buildings so that the BULLETIN would be the source of real information for those contemplating the erection of new buildings. College news items formed an important part of the reading pages of the BULLETIN and served as a bond of interest among the colleges. In addition a number of papers of considerable value which can not form a part of the proceedings of the Society were printed. The advertising pages, also, should not be overlooked as a source of valuable information. Through these the readers were made acquainted with progress in the publication of new books and the development of successful apparatus for the laboratory.

The Efficiency Papers.—The papers on efficiency which formed a considerable part of the proceedings of the Boston meeting may be considered under three heads: those relating to the fundamental principles of scientific management, that is to the content of courses in that subject, those relating to instruction in scientific management designed to produce efficiency engineers, and those relating to the application of the principles to the administration of college affairs. In making up the contents of this number of the BULLETIN the endeavor has been made to present material dealing with all phases of the subject. Mr. Shepard has prepared an exhaustive analysis of engineering education applying the so-called Emerson principles of scientific management to this class of administrative work. His varied experience has given him the material upon which to base conclusions. As a former teacher and dean he can sympathize with instructors in their endeavors to prevent mental and physical waste. Mr. William Kent, in his graphic, forceful way, emphasizes the need of gather-

ing real data regarding the effects of educational methods and he outlines a definite, although expensive, scheme for doing it. It is to be hoped that this suggestion will arouse discussion and produce results.

The papers by Messrs. Wolf and R. T. Kent deal with the problem of impressing the principles of scientific management upon technical students. These papers show the necessity for illustrating the theory by showing its application. In this point of view the authors are in line with modern methods in the teaching of all practical subjects. Dean Goss and Professor McKibben take up certain aspects of the subject in detail. They speak from their own successful experience in overcoming faults which interfere with efficient instruction.

The Mathematics Report.—During the past month the report of the Committee on Teaching Mathematics to Engineering Students has been widely advertised and well received. It is the result of the kind of work which the Society may well be engaged in. The report should be known to every student of engineering and its use as a reference text should be encouraged by teachers of mathematics and of engineering. The immediate duty of the members of the Society appears to be to disseminate information regarding this report. The Publication Committee will carry out any practicable suggestions in this line.

The Proceedings of the Boston Meeting.—The Boston program was devoted largely to conferences on the "operating characteristics" of college courses. The records of the meeting are voluminous. The chairmen of the several sections of the meeting are cooperating with the Publication Committee in getting these records into form for publication. The papers by Professors Franklin and MacNutt were printed in the BULLETIN last spring. The "efficiency" papers are now running in the BULLETIN and will be published shortly as a separate volume. The section conference proceedings, which will appear in Vol. XX. of the *Proceedings,* cannot be printed in the BULLETIN for lack of space but the columns are open for

the use of the special committees which are at work endeavoring to formulate suggestions for improvement in instructional methods.

NEW MEMBERS.

By letter ballot, on August 15th, the Council elected to membership Messrs. B. H. Brown, L. H. Harris, Francis Mallory, I. F. Morrison, J. W. Muldowney, T. M. Roberts, L. B. Taylor and H. E. Webb, whose applications are listed on page 4 of the September BULLETIN.

APPLICANTS FOR ADMISSION.

GABRIEL, G. A., Professor of Industrial Chemistry, Iowa State College, Ames, Ia. 1912

NEWHALL, A. B., Instructor in Shop Work, Wentworth Institute, Boston, Mass. 1912

RANKIN, F. J., Instructor in Electrical Engineering, Colorado Agricultural College, Ft. Collins, Colo. 1912

SEATON, R. A., Professor of Applied Mechanics and Hydraulics, Kansas State Agricultural College, Manhattan, Kans. 1912

TAYLOR, F. W., Consulting Engineer, Highland Ave., Chestnut Hill, Philadelphia, Pa. 1912

TIVEY, J. P., Demonstrator and Assistant Lecturer in Engineering, University of Queensland, Brisbane, Australia 1912

SOCIETY BUSINESS.

President Magruder has appointed Professor J. C. Nagle as representative of the Society at the opening of the Wm. Rice Institute. He has also appointed Professor T. U. Taylor as alternate.

LETTERS TO THE EDITOR.

July 11, 1912.

EDITOR BULLETIN, S. P. E. E.,
Ithaca, N. Y.

Dear Sir: Owing to failure by one of the authors to send in on time our contribution to the discussion on our paper, "An Engineering Course for Underclassmen," may I ask that this letter be printed in the September BULLETIN, as an acknowledgment of the courtesy of those who offered the discussion? Our comment follows:

Very truly yours,
W. A. HILLEBRAND.

The sociability which raises Director Hayford's question is of the vocational order, to which we object, not for itself but because of the atmosphere in which it thrives and on account of the consequences that it entails. In a community composed, so far as social intercourse is concerned, almost exclusively of young and immature people, its interests and activities are, generally speaking, trivial. The exceptions are notable because they prove the rule. An intense, all-absorbing interest is developed in athletics, student politics and social affairs. The sporting page, Sunday supplement of the daily paper and light fiction serve as literature, while affairs of the world pass by almost unnoticed.

This is the competition which all of us have to face, but in isolated communities on the Pacific slope where industrial pursuits, aside from agriculture, mining and power distribution, are still embryonic, it creates a situation that is particularly acute, and in our opinion makes all the more necessary endeavor such as that described in our paper on "An Engineering Course for Underclassmen."

SUVA, FIJI ISLANDS,
June 8, 1912.

PROF. H. H. NORRIS, *Secretary,*
Soc. for Promotion of Engineering Education.

Dear Sir: I take the liberty to enclose herewith a short article for your consideration as a contribution to the BULLETIN. It is entitled "Should Engineering Text-books Give Answers to Problems?" and suggests a plan which I think is a new one and may be of interest to members of the Society. I have not had opportunity to try out this plan as I am not now teaching. But, as it offers a possible solution to a question which puzzled me when I was an instructor in engineering mathematics two years ago, I am offering it to your readers. I am,

Sincerely,
HOBART D. FRARY.

SHOULD ENGINEERING TEXT-BOOKS GIVE ANSWERS TO PROBLEMS?

BY HOBART D. FRARY.

This is a question often discussed and one upon which teachers disagree. Of late years there has been a tendency among engineering teachers to allow the student no answers to numerical and algebraic problems. Although the writer must confess a fellow feeling with the student who insists that he can accomplish more with answers than without, it is not his purpose here to uphold either side of the question. The object of this paper is to suggest a simple device which may be employed in text-book exercises to preclude the use or need of answers.

First, let me summarize the arguments for and against the answer book:

When answers are given to all problems,

1. One type of student will work backwards from the answer or if not that, will at least look at the answer before

solving the problem and unconsciously be influenced thereby.

2. A more conscientious student will refrain from looking up the answer till he thinks he has solved the problem. But he too will work for the answer and if he gets it, no matter how, will be perfectly satisfied. Such a student is apt to jump at the solution of the problem without reasoning it through logically; if his result is correct he gives no further thought to it, if not he does not scruple now to employ the answer to find the mistake. Thus he fails to gain self-reliance and above all that habit of rigorous thinking which is so important.

3. Nevertheless the fact that he has the answer before him induces the student to work problems just to see if he can get the answers given. He solves them as you would solve a riddle and gets considerable satisfaction out of it when he obtains the correct result. Certainly he is apt to misuse the answers; nevertheless they stimulate him to solve the problems.

When no answers are given.

1. The average student shirks; he does not work the problems. He sees no profit in working them since he can not know when finished whether they are correct or not. He will wait till he gets to class and trust to luck.

2. The conscientious student labors through the required quota of problems with a vague notion that he is doing them right, only to find perhaps, when he goes to class, that he has worked them all wrong. It may be he has made the same mistake in every one. This disheartens him. He stops working out problems beforehand and waits for the recitation when he can get the answers to some of the problems from the teacher or other students. These he perhaps solves by himself later so that, though his daily mark may be poor, he stands well in quizzes and review. But he loses much by this method.

3. Frequently teachers require the problems to be solved in notebooks and handed in. This method serves its purpose, although involving an immense amount of drudgery both for the student and the teacher. But it does not obviate the above

difficulties. In fact it introduces another, namely that students will copy from one another.

When answers are given to only a portion of the problems the effect is no better. The student solves only those problems to which he has the answers.

Now the plan which the writer wishes to suggest is to provide, in lieu of answers, check problems involving the answers of one or more preceding problems. Such a check problem may be of the same nature as the preceding ones or may involve, by way of review, some principle previously studied or it may consist in a simple numerical computation. In difficult problems there may be a check problem for each, whereas, when the examples are simple, one check problem may serve for five or six and involve the answers to all.

The advantages of this method seem to be,

1. The student is enabled to prove for himself that his answers are correct but can not very well work backwards to find a mistake. He thereby gains self-reliance.

2. It stimulates him to solve more problems than he otherwise would just for the satisfaction of proving to himself and all by himself that he can work them correctly. He has more of that interest which a man takes in an original investigation.

3. When he has solved two problems (or more) with the check problem and then finds that something is wrong he goes back over his work and examines it more carefully, or perhaps he works the problems all over again. This is good practice for him; he acquires thoroughness and ability to criticize his own work. If he finally fails to make the check problem check he goes to the teacher at once.

Such a method would not be equally serviceable in all subjects but could be used to advantage, I believe, in many cases especially in the more elementary mathematics.

CURVE PLOTTING.

BY EARL B. SMITH,

Assistant Professor of Experimental Mechanical Engineering, Drexel Institute, Philadelphia.

In reading technical literature and text books one is often confronted with different graphical representations of the same relation of two quantities or factors, and about the only reason for such differences is the fancy or the lack of uniformity of the authors.

In nearly all engineering schools, curve plotting or the graphical representation of data, results, and computations is required of the students. As this is so universally done in this country, why should there not be more uniformity in the methods? Not only is there a difference in methods and results among different schools, but in many schools there is no uniformity between the different departments—engineering, physics, etc.

For instance, to represent graphically the change of efficiency of a motor with the change of speed, one department will plot the efficiency values as abscissæ, and another department will plot these values as ordinates. As a result, when the student passes from one department to another he is confused and may never realize that his graph may be a picture of his data or results.

To secure uniformity among his students and to secure results in curve plotting that are rational, the writer has formulated the following instructions and rules for this work, which are issued to each student:

Curve Plotting.

Curves are usually plotted on cross-section paper, ruled both vertically and horizontally with fine lines equally spaced; each fifth or tenth line being ruled a little heavier than the others for convenience in counting. For most purposes paper that is ruled with 20 lines to the inch is best. The left-hand edge of the ruling is known as the y-axis, and the lower

edge as the x-axis. Distances measured vertical, parallel to the y-axis, are known as ordinates; and distances horizontal, parallel to the x-axis, as abscissæ.

The matter of the choice of an axis for particular quantities or values is largely determined by custom. The dependent variable is usually plotted as an ordinate, and the independent variable is usually plotted as an abscissa. Most experimental work is accomplished by arbitrarily changing some quantity, which is then called the "independent" variable, and observing the effect upon some other more or less closely related quantity called the "dependent" variable. Unless there is some special reason for not doing so, the independent variable should be plotted horizontally and the dependent variable plotted vertically. One very important exception to this is in plotting curves in connection with tests of strength of materials. Here the independent variable, load, is plotted as ordinates, and the dependent variable, deformation or strain, as abscissæ. The instructor may point out other exceptions to this rule, which by custom should be plotted differently.

Whenever designating the plot of a curve, it is usually done by such a phrase as, for instance, "efficiency *vs.* speed," the abbreviation "*vs.*" meaning "versus," or against. In other words, the dependent variable, efficiency, is to be plotted against the independent variable, speed. In speaking of a curve the dependent variable should always be named first, as above.

The proper choice of scale to be used on each axis in plotting a curve is of considerable importance in properly representing a law or result. Only by experience in curve plotting, and the knowledge of the principal laws of physics, is one able to choose the best scale for each axis. The scale need not be, and usually is not, the same on each axis. In general the scale for either axis should be chosen: (*a*) such that the curve may be easily plotted and read; (*b*) so the curve will cover as much of the sheet as possible; (*c*) so the curve will not lie too close to either axis; (*d*) so that, in some cases, a particular part of a curve will be shown to an advantage; (*e*) so the same axes will serve for plotting other curves on the same sheet; (*f*) the same axes may be used for other curves of different values, as in interposing curves for comparison and study of relation.

In plotting a curve each value or point should be carefully located and marked by some permanent mark. Most laws and experimental results are shown by a smooth, continuous curve, or straight line. Most experimental data, however, is subject to so many conditions and variations, with more or less error, that points plotted will not of themselves form a smooth, uniform curve. Then it is necessary to draw such a curve, not through all the points, but in such a position that it will, as far as possible, represent an average of all the points. When the variables do

not depend upon each other then the curve should usually be a broken line from one point to the next.

The use of logarithmic cross-section paper offers a means of representing most curves by straight lines. This paper is ruled with lines, both vertical and horizontal, beginning at the intersection of the axes and increasing in distance apart. Distances represent the logarithm of the number instead of the number itself. As, for instance, the spacing of the divisions on a slide rule. A law which may be represented by an algebraic equation of some power other than one, when plotted on the ordinary evenly spaced cross-section paper, is shown as a curve. If this same curve be plotted on logarithmic paper, the curve will be shown as a straight line. It is usually easier to locate and draw a straight line to represent the law or average of the points plotted than it is to draw a curve; then, if desired to represent the law by a curve, it may be easily transferred from the logarithmic to the ordinary cross-section paper.

Specific Rules.

Of no little importance is the necessity of neatness, completeness, and finish in curve plotting. The following are a few very general rules that the student should follow when plotting curves:

(*a*) The curve should, first of all, be a graphical representation of the whole report, or some part. The attempt should be made to have it so complete as to preclude any necessity for reference to tabulated data or other parts of the written report. Where necessary, explanatory notes should be included on the curve sheet.

(*b*) Where more than one curve is plotted on one sheet the points for each curve should be marked by some distinctive sign, a +, or small x, a small circle, or square, or triangle, etc. The center of whatever sign is used should be the location of the point. A dot should not be used, as it is often obliterated when the curve is drawn.

(*c*) Different curves on the same sheet should be represented by different colors of ink, or by different characters of lines, as a fine line, dotted line, dash line, dot-and-dash line, etc.

(*d*) Curves should be carefully located and first indicated by lead pencil. Then carefully and neatly draw in with ink. Use some curve-form for this, and never draw a curve *free-hand.*

(*e*) The curve sheet must have some title or heading, preferably one that will more or less explain what the curve is to show. If this is not possible, then an explanatory note should be included, just under a general title.

(*f*) If there be only one curve on the sheet, it need not have a name other than that which serves as the title of the curve sheet. If there are two or more curves on one sheet, then each curve must be named. The

name is preferably lettered along equidistant from the curve. Such lettering should not be *on* the curve, but at a distance from the curve equal to about the height of the small letters used.

(*g*) It usually presents a better appearance to draw a pair of axes inside of the edges of the cross-sectioning, and to place the scale and the name of each axis between this and the edge.

(*h*) The scale of the axes, that is, the value of the divisions from zero on, should be placed at *regular* intervals *along* each axis, say at each heavy line. And the *units* in which the quantity is measured *must* be stated. If one axis and scale represent two quantities, then both names should be stated.

(*i*) The value of the *plotted* points should never be placed along the axes. Neither should the *value of the point*, after it has been plotted, be placed *alongside* the point.

(*j*) As before stated, draw a smooth curve, or straight line, through the *average* of all the points. Do not draw a broken or wavy line that passes *through* all plotted points. If possible, extend the curve through its intercept with the axes.

(*k*) Neat and uniform lettering is of great importance. Never any writing, but always and only good printing, should appear on a curve sheet.

(*l*) When one curve is intended to show the cause of the variation in another curve, both curves should be of the same length, one above the other, and the scale of the independent variable of each should be the same.

(*m*) In locating a curve to be the average of the plotted points, do not give the first and last points undue weight. That is, for irregularly plotted points the curve seldom if ever passes through the end points. Such end points should have no more influence or weight in locating the curve than does any other point.

(*n*) The study of good examples of curve plotting is strongly recommended to the student.

These rules are submitted with the express purpose of securing criticism and suggestions on this line of work, which may lead to more uniform methods and results. The writer realizes that this subject of curve plotting is not one of great and vital importance, but it is one of those minor essentials in an engineering course, which, if done with a uniformity by all, will tend towards a better and more universal graphical language in engineering reports and literature.

COLLEGE NEWS.

University of Minnesota.—The past year has been a notable one for this University, for within that period it has completed and occupied five splendid, large, new buildings on its recently enlarged campus. The real estate for the enlargement of the campus cost $800,000, and the aggregate cost of these buildings, with their equipment, $1,236,500. They are the Elliot Memorial Hospital, Millard Hall, the Institute of Anatomy, the experimental engineering laboratory and the main engineering building, including two wings, one for the department of drawing and the other for the engineering library.—The Medical Department occupies the first three buildings mentioned, having just moved into the last two named and will be ready to take up the regular work therein, at the beginning of the coming semester. The College of Engineering occupies the last two, having just moved into the main building, the other having been in use most of the year. —A new modern heating plant for the University, to be a substantial part of the College of Engineering, is being erected and work is about to be begun on a new building for the College of Chemistry on the new campus, to cost about four hundred thousand dollars; at the College of Agriculture a fine, large building is approaching completion for the department of farm engineering.—Dean Shenehan spent a month's vacation in the West, visiting Vancouver, Seattle, Tacoma, Mt. Rainier and Portland; Professor Hans Dalaker studied mathematics at Cornell University for ten weeks of the vacation; Dr. H. T. Eddy has been engaged in original investigations in concrete construction; Professor George D. Shepardson, who had been studying at Harvard for the year, received the degree of Doctor of Science from that University, in June of this year.

Cornell University.—Dr. Willard J. Fisher, for some time an Instructor in Physics at Cornell University, has been elected

to the Professorship of Physics in the New Hampshire State College of Agriculture and Mechanic Arts, and has resigned his position at Cornell to accept the position to which he has been elected.—Dr. F. A. Molby has resigned as Instructor in Physics at Cornell University and has accepted a position as Assistant Professor of Physics at Indiana University, Bloomington, Indiana.

University of Illinois.—Professor E. C. Schmidt, in charge of the Department of Railway Engineering, has been commissioned by the Japanese Government to design a railway dynamometer car for the Imperial Government Railways. The car will be constructed in this country under the supervision of Professor Schmidt, and is expected to be delivered next spring to the representative of the Japanese Government. The work has been undertaken at the instance of Mr. S. Matsuno, Chief of the Motive Power Section of the Central Division of the Japanese Imperial Government Railways, who has supplied the general specifications for the design. Financial matters are to be arranged in this country with Mitsui & Co., Ltd., of New York.

Colorado School of Mines.—Last year a course in coal mining was added to the curriculum. The authorities of the school felt that a school of mines representing a state which produces over twelve million tons of coal per year and employs some 15,000 men in the industry should devote more time to the specific instruction which concerns that branch of mining. As a result about twenty-five men are now attending the coal mining classes. One of the first coal mines opened in the state is within one-fourth of a mile of the campus, while the Northern Colorado lignite fields, the Canon City domestic coal fields where longwall mining is carried on and the well known Trinidad bituminous coal field are all easily accessible to students for inspection trips.

SECTION II.

PAPERS FORMING A PART OF THE PROCEEDINGS OF THE SOCIETY.

ABSENCES FROM CLASSES ONE MEASURE OF INEFFICIENCY.

BY F. P. McKIBBEN,
Professor of Civil Engineering, Lehigh University.

To persons in charge of schools or colleges a study of student absences from classes is of great value, because the absences are to a certain extent a measure of the efficiency of the system. If the system is working well there are few absences from classes. If it is jogging along with friction and kept going only by the continuous effort on the part of those in control, the number of absences will be large. Viewed from this standpoint, therefore, efficiency can be said to vary inversely as the number of absences. In analyzing the problem of absences at any institution one should first make a systematic study of the underlying causes. Such an investigation will show that students absent themselves from classes because of the following reasons: Poor teaching; lack of interest on the teacher's part; uninteresting subject matter; sickness, either of the student or of his friends or relatives; conflicts between recitations because exercises in two different subjects occur at the same hour; other legitimate matters which take students away from their work; idleness; laziness; dissipation; and youthful neglect.

There are two general ways of dealing with the absence evil. In one, frequent written tests during the term and a final examination constitute the basis for determining each student's standing. In this system no attention is paid to absences by the instructor except that the student is graded zero at each written test or examination from which he absents himself. Clearly, the effectiveness of this method is dependent upon excellence of instruction and upon keeping the students ignorant as to when written tests are to be given. This is a good system, because few students will be absent if they realize

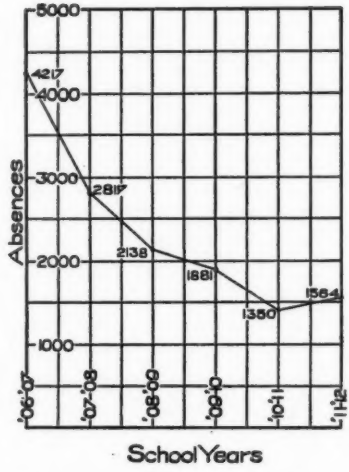
that a written test may be given at any exercise and that an absence from such a test is of very decided value in determining their academic status. The other system, which is in vogue at some schools, is that in which each student is graded

A = Total absences during course. B = No. Students x No. Exercises. C = Percent absences (A÷B)100

	Subject	1906-07 A	B	C	1907-08 A	B	C	1908-09 A	B	C	1909-10 A	B	C	1910-11 A	B	C	1911-12 A	B	C
1st Term	Sr. Bridge Des.	348	3240	10.7	172	2880	6.0	110	4536	2.4	103	5184	3.7	84	4536	1.9	71	3132	2.3
	Sr. Sanitary Eng.	236	3312	8.9	155	3020	5.1	134	2880	4.7	191	3240	5.0	87	2552	3.8	87	2160	4.0
	Sr. Geodesy	103	2160	8.0	136	2160	6.3	87	2108	4.1	115	1890	6.1	128	2052	6.2	44	1876	2.3
	Sr. Graphics (E.E.)	119	1944	6.1	127	1728	7.3												
	Sr. Graphics (Cn)							66	1188	5.5	80	1116	4.5	14	432	3.2	6	324	1.9
	Jr. Str. Materials	504	6005	7.5	452	8136	5.7	283	8835	3.2	200	7949	3.8	219	8209	2.7	244	6264	3.9
	Jr. Cement	102	1764	5.8	69	1545	4.5												
	Jr. Railroads	172	1800	9.6	134	1692	7.9	77	1656	4.0	51	1440	3.5	47	1440	3.3			
	Jr. Graphics (E.E.)	179	3744	4.8	153	3240	4.7	106	3146	3.4	84	3006	2.7	41	2520	1.6	25	1440	1.7
	Jr. Constrn (E.E.)	38	828	4.6	22	702	2.8	49	1296	3.8	16	720	2.2	9	1188	0.8	6	408	1.3
	Jr. Graphics (Mt.)							66	1080	6.1	60	1332	4.5	11	900	1.2	28	1368	2.0
	Jr. Fritz Lab.																9	594	1.5
	Jr. Roads & Pavts																86	1584	5.4
	Soph. Constr (E.E.)	80	1900	4.4	50	1650	3.0	37	1872	2.0	27	1440	1.9	16	1368	1.2	17	1368	1.2
	Soph. Stereotomy	145	3456	4.2	125	3384	5.9	133	3816	3.5	81	3672	2.2	34	2880	1.2	32	1998	1.6
	Soph. Ill. Mech. Mtr.													16	846	1.9	10	1278	1.5
	Fresh. Mech. Drg.										32	1476	2.2	23	1884	1.6	15	1136	1.3
	Totals	2175	30744	7.1	1675	30228	5.5	1147	32432	3.5	1169	32454	3.6	745	30396	2.4	630	24990	2.8
2nd Term	Sr. Bridges & Dsn.	271	3240	8.4	97	2880	3.4	78	3168	2.5				107	2160	5.0	99	1920	5.2
	Sr. Steel Bldgs.	92	684	13.4	28	900	3.1	15	828	1.8				10	756	2.5	15	448	3.4
	Sr. Cement													12	2052	0.6	55	1632	3.4
	Jr. Hydraulics	500	5924	8.3	339	6372	5.3	291	7020	4.1	306	6480	4.7	178	5778	3.1	324	5472	5.9
	Jr. Roads & Bridges	209	2754	7.4	121	2268	5.3	78	2592	3.0	51	2106	2.4	44	1836	2.4	151	2160	7.0
	Jr. My. Surv. (E.E.)	339	4590	7.4	184	3600	4.6	104	3610	3.0	115	3900	2.9	114	2880	4.0	85	2088	3.2
	Jr. Constrn (E.E.)	57	828	6.9	30	864	4.2	42	1044	4.0	75	792	9.6	14	1008	1.4	16	468	3.6
	Jr. Surv'g (E.E.)				75	972	7.8	59	1026	5.8	35	648	5.4	7	540	1.3			
	Jr. Hyd. Prac. Lab.																14	720	1.9
	Soph. Constr (E.E.)	135	1820	8.4	72	1512	4.8	161	1872	8.6	46	1440	3.2	20	1188	1.7	55	1215	4.5
	Soph. Surveying	230	3384	7.4	109	2952	3.7	70	2592	3.0	39	2016	2.4	39	2304	1.7	24	1472	1.6
	Fresh. Des. Geom.	194	2646	7.3	100	2700	3.7	84	2862	2.9	36	2214	1.6	51	2312	2.2	36	1632	2.2
	Totals	2004	25740	7.8	1145	25920	4.6	1041	28514	3.7	1712	29650	3.6	1605	28814	2.7	875	24908	4.4

Student Absences from Classes, C.E. Dept., Lehigh University.

frequently during the term upon daily recitations and upon written tests regarding which he has been previously informed as to their time of occurrence. In this system a number of absences is fixed for each subject, constituting a maximum limit beyond which the student must not go in absenting himself from class without suffering the penalty imposed for exceeding the limit. The penalty usually consists in exclusion from the final examination in the subject in which the absence



Total No. Absences from all Causes
Civil Engineering Dept, Lehigh University.

limit has been exceeded and the limit bears a certain relation to the number of exercises per week in the subject. For example, if there are three recitations per week in a subject the exclusion limit might be fixed at six, which is double the number of exercises per week. This ratio is too high; four would be a better absence limit in such a case. The very existence of an absence limit makes some students feel that they are allowed to take these absences, even though their

grades for exercises from which they are absent be zero, hence, this system is conducive to absences on the part of a few students if for no other reason than the inherent disposition in man to take all that is coming to him. Some students do not realize that the absence limits set are to meet unforeseen and unavoidable contingencies. It is unfortunate that the great number of worthy and careful students should be subjected to strict rules simply because there are a few irresponsible members in their ranks.

Believing as I do that absences are conducive to the formation of bad habits, which take time after graduation to overcome, and that an employer notices in many ways the effect of "dilly-dally" habits formed in college, I have tried to reduce their number in exercises taught in the civil engineering department at Lehigh University. That the effort has been successful is shown by the accompanying diagram and table, wherein it appears that in the six years beginning with the college year 1906–1907 the total number of absences in the department has been reduced from 4,217 in that year to 1,564 in the year 1911–1912. During this same period the percentage of absences has fallen from a maximum of 7.9 in the second term of 1906–1907 to a minimum of 2.4 for the first term of 1910–1911. The percentage of absences in any term is obtained by dividing the actual number of absences in all subjects by the product of the number of students and the number of exercises, and multiplying the quotient by 100. In the accompanying table every absence from exercises in the civil engineering department is included, whether occasioned by sickness, neglect, athletics, conflicts between two different subjects occurring at the same time; in fact, from every cause whatsoever.

This reduction has been accomplished by showing the students that it is for their good that they be present, by publishing the figures to show that an evil existed, by trying to make the exercises so interesting and important that students wished to attend, by unceasing watchfulness over and persuasion with those who showed carelessness, and finally where all

EXCLUSION. ABSENCE LIMITS FOR SUBJECTS TAUGHT BY CIVIL ENGINEERING DEPARTMENT, LEHIGH UNIVERSITY, 1911–1912.

	Subject.	Class.	Number of Exercises per Week.	Exclusion Limits.
First Term.	Bridge design	Senior	6	7
	Sanitary engineering	Senior	4	6
	Geodesy	Senior	3	5
	E. M. graphic statics	Senior	2	3
	Strength of materials	Junior	4	6
	Testing laboratory	Junior	1	0
	E. E. construction	Junior	2	3
	Roads and pavements	Junior	2	3
	C. E. graphic statics	Junior	2	3
	M. E. graphic statics	Junior	2	3
	Elem. mech. of materials	Sophomore	1	2
	C. E. construction	Sophomore	2	3
	Stereotomy	Sophomore	3	5
	Mechanical drawing	Freshman	2	3

	Subject.	Class.	Number of Exercises per Week.	Exclusion Limits.
Second Term.	Bridges	Senior	4	5
	Cement and concrete	Senior	3	4
	Steel buildings	Senior	2	3
	E. E. construction	Junior	2	3
	Hydraulics	Junior	3	4
	Bridges	Junior	3	4
	Railroad surveying	Junior	4	5
	Hydraulic laboratory	Junior	1	0
	C. E. construction	Sophomore	2	3
	Land surveying	Sophomore	4	5
	Descriptive geometry	Freshman	3	5

other means failed by enforcing strictly the rule regarding exclusion from final examination where the absence limit had been exceeded. This exclusion meant that the student under discipline was compelled to repeat the subject in class. A very forceful argument that sets the students to thinking about this matter is that pertaining to the financial aspect of the question. Let it be supposed that a student has 18 class exercises each week for 30 weeks or 540 exercises during his college year and that the total cost of his year's stay at college is $810.00. If he is absent once he has wasted $1.50, assuming that each exercise is of the same importance; 10

absences means the loss equivalent to $15.00. Of course, the reasoning here is far from logical, because a boy will not lose the entire lesson by being absent from the recitation if he has devoted some thought to the lesson at home, but there is just enough basis for the argument to make some students understand the point involved and to make them improve their attendance.

ACADEMIC EFFICIENCY.

BY WILLIAM KENT,
Consulting Engineer, Montclair, N. J.

About ten years ago I was asked by the president and general manager of a large manufacturing corporation to advise him how to improve the performance of his boiler house. During the previous winter it was pushed to its utmost to deliver enough steam to run the engines and to keep the buildings warm, and the next winter, on account of extensions to the factory and increased output, the demand for steam would be still greater. Before beginning my work the president told me something of the history of the company, and of how he came to be the general manager. It had grown in fifty years from a small concern to a large one, occupying several blocks of ground. The business was the manufacture of a variety of shelf hardware. He had for several years been a director and the manager of the sales department, and on the death of the former factory manager the directors insisted on his taking the place, although as he said he knew nothing about running a factory. He started in to learn how by calling in the best outside expert advice available. He was paying $10,000 for a year's services of a highly skilled expert in machinery, jigs, and methods of manufacturing, who was making a revolution in the shop, which amply justified the high price paid for his services. This man said he knew nothing about boilers, and therefore I was called in to tackle the boiler problem. Incidentally the president told me that the catalogue of the products made by the concern contained 14,000 items, each of which involved patterns, pigs, templates, storage, book-keeping, records and correspondence. Probably half of these items were either obsolete or in very small demand, and another large fraction were unprofitable to handle. Another $10,000 might have been properly spent in

making a selection of which of the 14,000 items should be abandoned and in printing a new catalogue.

In regard to the boilers, the president told me I could get all information available from two men, the superintendent of the factory and the chief engineer, who were at loggerheads. One had told the president one story about the boilers, and the other an opposite story, and he did not know which one to believe. He called the superintendent into the office to tell me his story, and, dismissing him, called in the engineer who told me the other story. I then had the engineer take me through the whole factory, including the power plant. On my return to the office I told the president that the engineer had told the facts, and that the superintendent had not because he was ignorant; he knew nothing about a power plant and never would know, for his bump of conceit was too great to permit of his learning. I reported further that the trouble from lack of steam was not the fault of the boilers—there were about 25 of them, crowding the boiler house to its capacity, and there was no available land for an addition to it—they were making as much steam as they should be called on to make with due regard to economy of fuel; but the trouble was entirely owing to the great waste of steam throughout the factory in winter time. Live steam was used for heating, and numerous traps were wasting both steam and hot water. As a result of my investigation an exhaust-steam heating system was installed, and that stopped all complaints of the insufficient supply of steam.

This long story about a factory may seem to have nothing to do with academic efficiency, but there are several points of resemblance between its condition and that of some educational establishments. They, like it, are suffering from inefficient management continued through a long period of years; they have too many items in their catalogue; heads of departments at loggerheads; a board of directors who are capitalists, but who know nothing of the details of the business they are supposed to direct; a president and general manager who is well versed in the advertising part of the business, but

knows nothing of the best ways of producing its product. The factory, however, has two points of difference from and advantages over the college. (1) The competition of its rivals forces it to improve its methods, while the college has no such stimulus to improvement. (2) The manager of the factory referred to knows that he knows nothing about the best way of running a factory and therefore calls in outside expert assistance, the manager of the college thinks he knows it all, and therefore has no need of advice.

I said some educational establishments, not all. There are others, and this brings me to another story. It is about a university.

A certain large university more than twenty-five years ago had an engineering college that was already suffering from dry rot, although it was only about ten years old. It had a good location, excellent buildings and equipment, and ample funds, yet the college had lost prestige, and the number of students was decreasing. The president of the university knew nothing about engineering education, but he was wise enough not to pretend to know anything about it. He asked half a dozen or more consulting engineers and engineering professors to visit the college and independently to give him written reports as to what ought to be done to improve the college. I was one of the visitors. I found that the college was divided into two independent departments, one theoretical and the other practical, each presided over by a professor who was responsible only to the president. I spent a morning with one of these professors and an afternoon with the other. Each told a tale of woe, about the utter worthlessness and total depravity of the other man. I advised the dismissal of both, and the appointment of a man who was big enough to be the head of the whole college. Some months were spent by the president of the university in getting these reports and in interviewing different experts, including men whose names had been suggested as qualified for the position. He selected the right man, gave him full authority, approved his every request, and the trustees gave him everything he asked for in

the way of competent assistants and additional equipment. The theoretical professor resigned, and the practical one gracefully subsided into a minor subordinate position, where he gave no trouble. The college grew with great rapidity. In ten years it was in the front rank of the engineering colleges of the world, which position it still holds.

Note the points of similarity between the factory and the university as related in these two stories. Each was suffering from inefficient management, each had a president who was ignorant of the details of the business, but who was conscious of his ignorance and was willing to take advice from outside. In each case the advice was taken, with the best possible results.

My subject is entitled Academic Efficiency. I use this short term merely because it has been used before to mean the efficiency of educational methods, and it may be necessary to explain that the word "academic" here means relating to an academy or educational establishment, and not, as it sometimes means, "unreal" or "unpractical." The word efficiency is often used with different meanings. Dr. Eliot, ex-president of Harvard University, in his little book on "Education for Efficiency" defines it as "effective power for work and service during a healthy and active life," and he says "national education will be effective in proportion as it secures in the masses the development of this power and its application in infinitely various forms to the national industries and the national service." The engineer uses a more restricted and technical definition, the quotient of output divided by input, or the relation or ratio of the result achieved to the effort in obtaining it. Mr. Harrington Emerson objects to this definition as insufficient in its not including an equitable standard of achievement or output as one of its factors, and defines efficiency as the "relation between an equitable standard and an actual achievement," or "the relation between what is and what could be."

Strictly speaking, the engineer's definition is limited to cases in which both the input and the output may be

measured in the same unit, or in units that are convertible one into the other, such as foot-pounds and heat-units, but it is a convenient definition for many cases in which neither the whole output nor the whole input are capable of accurate measurement in similar terms. For example,

We spend or give:	We get or gain:
Input.	*Output.*
Time,	Money or saleable goods,
Money or raw material,	Health,
Physical labor,	Recreation,
Mental labor,	Education,
Nervous energy,	Satisfaction.
Health,	
Wear and tear of machinery,	

If we take the engineers' definition expanded in this way so as to include in the input every conceivable kind of expenditure and in the output every conceivable kind of achievement, it will apply to every activity of man. The efficiency while it cannot be stated in figures, as a percentage, is measured by the value of the output in relation to the input or expenditure. Thus a business man may spend every one of the items listed under the head of input, and measured by a money standard the result may show a high efficiency, but measured by a broader standard, in which the result as to health is a negative quantity, it is most inefficient. Then if he takes to golf playing he may spend time, money and physical labor, and gain health: The efficiency by the money standard is zero, but by the broader standard, including health, recreation and satisfaction, he may consider that the efficiency of the operation is 100 per cent.

A college spends all the items listed under "input." Its efficiency is zero from the money standard, for its business is not to make money, and may be high or low measured in the other items listed under output. By Mr. Emerson's definition, the relation of an equitable standard to the actual achievement, or the relation between what is and what could

be, we compare the actual output in health, recreation, education and satisfaction, with what might be realized under the best possible conditions of system and management. Are the results what they ought to be in kind, in quality or in quantity, and if they are not, what are the defects and how can they be remedied?

In the big factory of which the story has been told, the product included 14,000 items, many of which should have been abandoned, and much of the inefficiency was due to the factory's making products that should not have been made. When an efficiency expert begins his operations in a factory his first questions are: What kind of product is made? Why is it made? Why not abandon it if it is not profitable? The same questions might be asked of a college. The next set of questions covers the quality. Is the quality too highly refined and too costly, so that its market is limited? Is it too common and cheap, so that it has to be brought into competition with the poorest goods on the market? Is it out of date and unfashionable? Is the quality what it ought to be, and if not what are the reasons, and how can it be improved? Surely these questions may be asked of a college, and it is the general belief that the answers would not be complimentary to the college. There are serious defects in the quality of the college product.

Next come questions as to quantity. Is the factory turning out too much of one kind of goods, so that the market is glutted and the price too low? Is it turning out too little, so that it is not doing as much business as it might do? Is it turning out too much of one kind and not enough of another; and if so, what changes should be made so as to establish a proper balance? Is the college overcrowding the professions with men who are not needed in them? Is it failing to supply the demand for the kind of men who are needed? The common opinion is that both of these questions must be answered in the affirmative. The last report of the Carnegie Foundation for the Advancement of Teaching says, "In almost every state of the Union there are more colleges in name than the

country needs or can afford. They have been started without much regard to the ultimate educational demands—weak and often superfluous colleges. In many cases their existence makes impossible that of good high schools which would far better serve the educational interests of the community."

After these questions of kind, quality, and quantity of product are considered, then comes the question of cost per unit of product and of possible methods of reducing that cost. In the factory the solution of these questions is one of great difficulty and complexity. It includes the items of location, buildings, machinery, system of organization, functional foremanship, statistics, accounting, planning of work, routing it through the shop, methods of payment of wages, keeping high-priced men only on high-priced work and finally time study resolved into its elements, that is motion-study. I quote from Frank B. Gilbreth's new book on Motion Study:

"There is no waste of any kind in the world that equals the waste from needless, ill-directed, and ineffective motions. . . . Tremendous savings are possible in the work of everybody—they are not for one class, they are not for the trades only; they are for the officers, the schools, the colleges, the stores, the household, and the farms. . . . It is obvious that these improvements must and will come in time. But there is inestimable loss in every hour of delay. The waste of energy of the workers in the industries today is pitiful. . . . In the meantime, while we are waiting for the politicians and educators to realize the importance of this subject and to create the bureaus and societies to undertake and complete the work, we need not be idle. There is work in abundance to be done. Motion study must be applied to all the industries. Our trade schools and engineering colleges can:

"1. Observe the best work of the best workers.
"2. Photograph the methods used.
"3. Record the methods used.
"4. Record outputs.
"5. Record costs.
"6. Deduce laws.
"7. Establish laboratories 'for trying out laws.'
"8. Embody laws in instructions.
"9. Publish bulletins.
"10. Coöperate to spread results and to train the rising generation."

Mr. Gilbreth refers to motion-study of the industries that are producing material wealth, but his words may be applied to the industry of educating men and women, that is to the schools and colleges.

The methods of reducing the cost per unit of product in industrial concerns have now been reduced to a science by the management experts, Taylor, Gantt, Emerson, Parkhurst and others. In educational circles only the merest beginning has been made. Bulletin No. 5 of the Carnegie Foundation for the Advancement of Teaching, a quarto pamphlet of 134 pages, entitled "Academic and Industrial Efficiency," contains a report by Morris Llewellyn Cooke of the investigation of the department of physics of eight different colleges or universities. Mr. Cooke has had several years' experience as expert on management of industrial works, and is now Director of Public Works of the city of Philadelphia. His report is only a preliminary one, and covers little more than a statistical investigation of the cost of instruction in physics per student-hour, and some observations on methods of administration, and on the economical use of buildings and of the time of the professors and instructors, in all of which he found great differences. The total cost of physics per student-hour at Harvard was $1.08 and at Wisconsin $0.60. Of these totals the interest on plant and equipment and administrative expense account is $0.53 at Harvard, and $0.18 at Wisconsin. There are differences in the colleges which are far more important, however, than those that can be expressed in dollars and cents. For example, Mr. Cooke found one in which the professors showed the heartiest interest in the progress of each individual student, and another in which "every time the students were mentioned, there were evidences that the teachers had in mind the students' scholarly inferiority and waywardness."

The cost per student-hour for any subject may be obtained as in Mr. Cooke's investigation. It will be a far larger task to determine the efficiency of the student-hour—that is what return in valuable education the student gets for the expendi-

ture of the thousands of student-hours that he spends in college. We have as yet no standards of measurement by which educational efficiency can be satisfactorily measured, but it cannot be doubted that some day such standards will be found, when well qualified experts are employed to find them. For a method of obtaining such a standard in English composition, see the writer's paper in *Proceedings of the Society for the Promotion of Engineering Education* in 1907 on "An Experiment in Teaching English to Freshmen in a University."

Efficiency, according to the engineers' definition, is the relation of output to input, or the relation of the result to the effort and cost expended in achieving it. From the college student's standpoint, the input is four years of time and say $2,000 to $4,000 in money. The output is what he receives for that amount of time and money. Let us put what he receives in tabular form under two heads, life and study.

Life	Study		
Acquaintance.	Cultural.	Disciplinary.	
Companionship.		Information.	
Fraternity.	Technical	Foundations of Science and Art.	
Social Activity.			
Athletics.	Vocational	Relating directly to life work.	
Reading.			
Leisure.	Curious	Non-useful or dilletante.	
Travel.			
Moral Uplift.			

How many hours out of the 24 in a day are student-hours, and how many are devoted to so-called college life? Is his time properly divided between the activities of life and study? Of the student-hours is there the proper balance between the cultural and the other branches? How and by whom is this balance determined? Which of the courses are prescribed and which are elective, and why? What text-books are used, and why? Are particular courses taught by the text-book and recitation method, by the lecture and note-book method, by the problem method, or by the laboratory method? Is each teacher free to use his own method or is the method determined on by a department head or committee or by other

authority? What experimental pedagogical work has been done to discover the relative efficiency of different methods? What are the results of such experiments? Have they been reduced to statistical form and published? What is the administration doing to improve educational efficiency? Is there any method employed to measure the relative efficiency of different teachers, or of the same teacher in different years or when using different methods? How are the tenures of office, promotion, salary, etc., determined? How are poor teachers got rid of or transferred to other positions in which they may be more efficient? What is the organization of the college, and what are the efficiencies of the board of trustees, the president, and the heads of departments? If an investigator like Mr. Cooke, or preferably a commission of investigators, were to report to the Carnegie Foundation answers to these questions after a year's examination of a dozen or more institutions of learning, it is safe to say that an appalling lack of efficiency would be disclosed. The commission would find every grade of goodness and of badness in the teaching staff, teachers generally overworked, underpaid and dissatisfied and on the lookout for positions elsewhere. It would find self-perpetuating boards of trustees responsible to nobody, individual trustees chosen not for any educational qualification, but solely because they are men of wealth and influence; presidents chosen through personal or political favoritism, whose ideas of education are those of the middle ages, and whose methods of government are those of the tyrant. It would find the conditions mentioned by President Benton, of the University of Vermont, in his inaugural address, 1911, namely, the election of new members of the faculty dependent entirely on the dictum of the president, "the administrative office a veritable cesspool where unpleasant experiences are deposited," "a coterie of professors painfully sycophantic in the presence of their 'lord and master' and bitterly denunciatory of him when left to themselves," "reprehensible hypocrisy by those who teach," etc. President Benton seems to be unaware of the fact that the sycophancy and hypocrisy

which he thus bewails are the inevitable results of government by an ignorant despot, and that they can be done away with only by a radical change in the system of government. I do not wish to be understood as believing that the conditions thus described are universal. There are many institutions in which there is no autocratic government, and in which the government approaches in some respect to democratic ideals, where free speech is possible, where merit is recognized and rewarded, and where the teaching methods are constantly being improved. Here and there we find evidences of attempts to find the best methods, and of new experiments in education whose results are very promising, for example, Professor Franklin's improvement at Lehigh in the method of teaching laboratory physics; the examination of the English teaching in different technical schools by Professor Earle, of Tufts College, the introduction of the preceptorial system at Princeton, Professor Schneider's coöperative system in Cincinnati, the university extension work at Wisconsin, the investigation by a committee of the Society of American Bacteriologists of the teaching of microbiology; and Dr. Rumley's experimental preparatory school at Interlaken, Ind.

Mr. Harrington Emerson has written a book entitled "The Twelve Principles of Efficiency." He wrote it with especial reference to the efficiency of manufacturing establishments, but the principles may be applied to educational institutions. They are the following: (1) Clearly defined ideals. (2) Common sense. (3) Competent counsel. (4) Discipline. (5) The fair deal. (6) Reliable, immediate and exact records. (7) Despatching. (8) Standards and schedules. (9) Standardized conditions. (10) Standardized operations. (11) Written standard practice instructions. (12) Efficiency reward. The investigating committee might use this list of twelve principles of efficiency in its examination of the colleges and find to what extent they are in operation.

Suppose that the Carnegie Foundation were to have an investigation made such as is here suggested, what good would it do? The same good that Mr. Cooke's investigation of the

cost of the student-hour did, and something more. It would call public attention to the subject, and might lead some universities to reform some of their methods. It would reveal how bad things are, which is the first step toward reform. The report would be denounced as Mr. Cooke's has been, by college presidents and by editorial writers of conservative ways of thinking, as utterly subversive of all the ancient educational ideals, and involving "a gross and fundamental error." But it would set men thinking. It would show them that some universities and colleges and some educational methods are better than others, and give the public some knowledge which would enable them to select the best colleges, and some educators of a progressive turn of mind the information they are looking for in regard to methods.

The best possible result of such a report, however, might be that it might induce some multi-millionaire to think that he had a duty to perform in helping to improve the efficiency of educational methods, by contributing the funds that would be required to carry on an educational experiment similar in extent to the experiments carried on by Mr. F. W. Taylor in the Midvale and Bethlehem Steel Works. It required more than twenty years of labor and the expenditure of some hundreds of thousands of dollars to carry on his experiments on tool steel, which have revolutionized machine-shop practice, and on scientific management, which bids fair to cause a far more important revolution in all our industrial systems. Mr. Taylor's system of management cannot be adopted without many modifications by an educational institution, but his system of experimentation can be. It is simply the careful collection of all the facts by an expert, their study by mathematical methods, the making of experiments to get more facts, their further study, and careful reasoning to arrive at correct conclusions. It takes years of time, thousands of dollars of money, and can only be undertaken with any probability of reaching valuable results by a scientific expert who is entirely unhampered by old traditions. The motto of the conservative is "whatever is, is right," that of the scientific expert

is, " whatever is, is apt to be wrong; I am going to test it and find out whether it is right or wrong."

Here is the outline of an educational experiment to take ten years of time and cost half a million of dollars—less money by the way than one second-class university has spent on its equipment for athletics within a few years, and less than has been paid by some millionaires for a couple of paintings.

Appoint a commission of five well educated men who are not connected with any educational institution, say a minister, a doctor, a farmer, a merchant and an engineer, to secure a wide diversity in points of view. Pay them $5,000 a year each for the first year, and a smaller sum in succeeding years, when their time will not be fully occupied, and provide them with an office, stenographer and clerk, and funds for traveling expenses. Let them spend a preliminary year in investigating actual educational conditions in this country, collecting facts, statistics and expert opinions, on which they should prepare a report. They should also report their opinion on what should be the course of education of a boy between the ages of 14 and 16, if he intends to go to work in the mechanical trades or in commerce at the age of 16, also what should be the course from 14 to 18 (1) if he intends to go to work at 18, (2) if he intends to enter a general college, (3) if he intends to enter a technical school. The second year the experiment is to be begun. Select a hundred boys who are ready to enter high school, of the majority of whom there is a reasonable probability that they will, if they prove fitted for it at 18, take a college course. Rent a preparatory school, or a portion of one, and have the boys taught, by selected teachers, in the courses laid down by the commission. Provide enough tutors or preceptors to insure that the education of the boys is properly supervised and that their time is not wasted. Continue their high school education, for as many of them as stay in school, for four years. During all their time the commissioners are to be studying methods of teaching, and methods of measuring the efficiency of teaching, preparing practical standards of examination, not merely to test the

memory of the scholars, as in ordinary examinations, but to test their mental and bodily powers. Find out not only what the boys know, as a mere act of memory, but what and how they think, and what they can actually do. Test not only the hundred boys, or as many of them as remain, but also boys in other high schools, by the same standards or by other standards that may be proposed by the high school teachers. Cultivate the same spirit of emulation for success in scholarship that now exists for success in the athletic field, but give them also enough athletics and other recreation to develop their bodies as well as their minds. Train them also in hygiene, in morals and in manners, to make them not only scholars but gentlemen.

During these four years the commissioners are also studying college administration, courses, methods of teaching, and efficiency, and determining standards of measurement of efficiency. When the boys are through their preparatory course of four years, send them to such colleges as have been selected for them, have them take the courses for which they are fitted, provide tutors for them, and watch their progress through the college, testing them by predetermined standards in comparison with other college students. At the end of the four-year college courses, the commission is to report on the whole eight years' experiment. It will be found that many mistakes have been made, but probably not so many as would be made in an ordinary eight-year course of high school and college. The success of the experiment is not to be judged by the success of these selected boys, but by the value of the information obtained and reported on by the commissioners as to the various methods of teaching and of college administration and by the acquirement of standards by which academic efficiency may be measured in the future.

During the whole of the eight years' experiment the boys should be required to keep a diary in which they record what seem to be the most important items concerning their education, and they should once a year present to the commissioners a written report of their progress, keeping a copy for their

own future use. Four years after they have graduated from college, when their minds are sufficiently mature, they should be asked to write critical reports of their educational career as it then appears to them. A study of these reports by the commission, which should be continued in existence for that purpose, would no doubt furnish fruitful ideas for further educational progress.

Cecil Rhodes did a noble work in establishing the foundation of the Rhodes Scholarship in Oxford. Andrew Carnegie has done a grand work in establishing the Carnegie Institute for Scientific Research and for the Advancement of Teaching. Equally grand will be the work of him who shall establish a foundation for the application of the methods of scientific management to the improvement of academic efficiency.

This proposed plan is merely a suggestion. There may be a better plan, but whatever it may be it will take years of hard work and a large sum of money to accomplish the desired results. It might be undertaken by the Carnegie Foundation for the Advancement of Teaching, by the Russell Sage Foundation, or by the government, but the funds of these foundations are probably already fully employed, and judging by the past non-activity of the government in educational matters it might take twenty years of agitation before Congress could be induced to make the necessary appropriation. The government has a department of agriculture which is making experiments for the farmer, to enable him to grow larger and better crops, a bureau of forestry which is trying to conserve our forests, a bureau of mines which is experimenting on improving the methods of mining and on the prevention of accidents. It has also a bureau of education, which publishes statistics of schools and colleges and some interesting papers on educational subjects, but which has never investigated academic efficiency or carried on an educational experiment. All educational reforms in this country have been originated by individual philanthropists or by individual universities. They do not come about by normal process of evolution in the educational world or by govern-

mental action, with perhaps a single exception, the Morrill Land Grant Act of 1862, just fifty years ago. We therefore must look for a millionaire philanthropist to begin the great educational experiment which will lead to improving the methods of training our future citizens.

Our modern educational literature, addresses of college presidents and school superintendents, proceedings of societies, etc., all show the prevailing consensus of opinion that there is something seriously wrong with our whole educational system, and that instead of getting better it is constantly tending to grow worse. There exists also a great amount of ultra-conservatism and of mental inertia relating to the subject. It is high time that something practical be done in the way of reform.

THE ADMINISTRATION OF COLLEGE SHOP LABORATORIES.

BY W. F. M. GOSS,

Dean of the College of Engineering, University of Illinois.

The shop laboratory has for many years constituted an important factor in technical education. The Worcester Polytechnic Institute, which began its work in November, 1868, gave a prominent place to such laboratories. A shop laboratory was organized at the University of Illinois in 1870. An elaborately equipped shop for the administration of graded courses of practice, in conformity with the so-called Russian system, was established at the Massachusetts Institute of Technology in 1876, at Purdue University in 1879, and soon after in various state universities and in other institutions.

Several important results have followed the establishment of these shop laboratories. Their work has interested the public. In the early development of engineering courses in the state institutions of the Mississippi Valley and the west, it was important that the work undertaken should be readily interpreted by the public. The forgings, the patterns, the castings and the finished machines resulting from the work of students in the college shops were accepted by the supporters of these institutions as evidence of the practical character of the work done by the college. Many institutions which began with the simple processes of the shop, have so stimulated the confidence of their supporters that they have been able gradually to build up courses of greater breadth and value. It is especially true of the state universities, that the shop laboratories, with the field instruments used in surveying, have served as stepping stones in the upbuilding of the present-day broad and admirable courses of study and practice.

Advocates of the movement have looked upon the work of

the shop laboratories as of the highest importance from an educational point of view. Such work has trained students to an understanding of the nature of materials, and has afforded them practice in many of the fundamental processes which underlie all construction. Its purpose has been not to make men skilful manipulators, but to give them an understanding of the principles governing manipulation. Not only have the shop laboratories accomplished this purpose, but they have bestowed upon students certain incidental advantages. The fact that a graduate in mechanical engineering has been able to run a lathe has often supplied a way for his admission to an establishment, in the management of which he has later become an influential factor. In the early days of the technical school, the fact that the engineering graduate could make tests and calculate the efficiency of a boiler counted for little, but the fact that he could take his place in a shop and do things which the practical men of the shop were paid for doing, at once gave him value in the opinion of the men who were influential in determining his future career.

Many changes have affected the engineering industries since shop laboratories first made their appearance, and many new conditions have arisen which must be taken into account when one attempts to define the present-day conduct of such laboratories. Much of the shop work formerly done by the college is now being very well done by the secondary school. The practicing engineer and the corporation manager, who employ the technical graduate, no longer require him to be a skilful manipulator. The employer is now willing to accept at its face value a candidate's ability to apply correct theory in the analysis of practical problems, and he does not insist that he shall be able to compete with skilled workmen as a workman. A demand has developed for men possessing other characteristics—the characteristics of the well-trained theorist and analyst—for men who understand the principles underlying the work of the mechanic, and who through the application of these principles can aid in a large way in increasing the efficiency of the establishment they serve. The people

contributing to the support of the technical school no longer require the activities of the shop laboratory to convince them of the value of the engineer's training, for they see in the work of men who control the engineering activities which are going on all about them, a better and a broader definition of the true functions of the engineer.

From these considerations it should be apparent that the ideals which hitherto have stimulated the work of the shop laboratories are sustained by arguments which are losing force as time proceeds. So true is this that the question is already fairly before the technical school as to whether the existing shop courses which have served so long and so well shall be entirely abandoned. If not abandoned, they must be placed upon a new plane of excellence.

In the opinion of the writer, the time has come when the shop laboratory should cease to be content with a grade of work possible in a secondary school; its work should possess a quality and character which is only possible in the environment of the technical school. This implies that the work of the shop laboratories must be interrelated with that of other technical courses, that such laboratories must cease to use equipment which was purchased one or two decades ago, and that they must cease to be satisfied with methods of administration which, in the actual shops, have already passed out of existence. If the shops are to mean anything worth while, they must not only respond to the great and significant changes which have been going on outside, but they must have their part in leading such changes. Their work must not stop with a routine; it must proceed to the development of research that new principles may be established. This means that the administration of laboratories which are to serve such purposes must be in the hands of broadly trained men and that sufficient funds must be available to permit their operation on a scale far beyond that which most of our institutions have as yet thought possible; it means that such laboratories will take their place with courses of instruction touching the principles underlying systems of shop production just

as the steam-engine laboratory has taken its place in connection with class room courses in thermodynamics.

This conception makes the problem of the modern shop laboratory one of large proportions, and its solution presents a field of endeavor which the officers of technical schools will find full of promise.

TEACHING SCIENTIFIC MANAGEMENT IN ENGINEERING SCHOOLS.

BY ROBERT B. WOLF,

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It is not my purpose to go into an elaborate discussion of the principles of scientific management, but simply to give briefly my reasons for believing that it should be taught in our engineering schools. In this day of keen competition no manufacturing establishment can be conducted successfully by the old "rule of thumb" methods. This is especially true in that class of manufacturing which has been established for some time and where competition and increased cost of raw materials have reduced the margin of profit. There are quite a number of establishments, such as machine shops, foundries, etc., where the principles of scientific management have been worked out to a very fine point by Dr. Taylor and others. Any one starting out in this line of work need not be put to the trouble and expense of conducting a long series of costly experiments to determine such a question, for instance, as the proper method of cutting metals. A thorough course outlining these principles can well be added to the curriculum of our engineering schools. This course should describe in detail the methods used in up-to-date machine shops, going into the subject of "time study" work, store system, and general accounting, which will undoubtedly save many a young engineer from spending his time going over the ground already covered by others. He could then devote his energies to extending the field still further.

In some industries the principles of scientific management have been so well worked out that it is hardly any longer a question as to what are the best methods to pursue. If the engineering schools will take up this subject, it will enable the students to profit by the experiences of others, thereby

tending towards ultimate economy in manufacturing methods. The very excellent treatise on the art of cutting metals, by Dr. Taylor, might well be used as a text-book, even though the student does not intend to follow machine-shop work. A careful study of this book, so that the principles involved are recognized, will assist materially in pointing out the general methods that should be followed in pursuing any line of investigation. These identical principles have been adopted, for instance, in the cooking or boiling of pulp in sulphite digesters.

A course describing the methods in use in making motion-study might well be added, as this is an important part of scientific management. As an illustration of this, there is one large pulp manufacturing concern that was able to save over $200 per day in freight paid to the railroad companies, by a careful motion-study to eliminate lost time in the operation of its hydraulic press equipment for pressing moisture out of the pulp. There should also be included a course describing the various methods of rewarding men for their increased efficiency. This must be gone into very carefully in order to point out the danger of attempting any kind of piece work or bonus system, without scientifically determining in advance the best methods to follow. Mistakes made by imitators of scientific management might have been avoided if a more thorough knowledge on these subjects had been available. The methods for rewarding foremen and department heads, so that they will be stimulated to their best efforts, should also be studied, as well as those used to determine the departmental efficiencies.

Another important subject is the use of graphical methods for analyzing the results of investigation and keeping track of operating conditions. Considering the extreme simplicity of this method and the impossibility of obtaining intelligent results in any other way, it surely seems that this subject should be given a great deal more attention in our technical schools. There is nothing new, of course, about graphics, but its general application to business is new and should be studied.

All of this, of course, involves experience and it is highly desirable that the subjects previously referred to in this paper be taught by men who have had experience in putting these principles in operation. In my judgment it would be improper and might be productive of harm rather than good if college instructors simply took up the subject by text-book and attempted to teach it. The true principles of scientific management cannot be comprehended in this way alone, as the practicable conditions can only be learned by actual contact with the work and have a great bearing on the final conclusions. If this subject must be taken up by the regular instructors in the engineering schools, they should be given permission and time to go into the manufacturing establishments now operating under this system, to become thoroughly familiar with it. After having done this they will be in a much better position to teach the subject in an authoritative and interesting way.

After having acquired a knowledge of the mechanism of scientific management the student should also be taught the general philosophy of the subject and it would be well to include in this connection a course in biology and practical psychology, for the reason that the true test of scientific management is that it improves and elevates the mental and physical condition of the workman. A wrong impression has been given by some of the opponents of scientific management, who claim that it tends to make automatons of men. If this has been done in any of the industries it is because the true principle has been departed from and for this reason, if for no other, the treating of the subject in a comprehensive way in our engineering schools would be a great advantage, and would tend to prevent mistakes of this character.

One other thing that scientific management has pointed out very clearly is that the physical condition of the men should be considered to its fullest extent and that the men who are overworked and working in unhygienic surroundings are in the very nature of things bound to be more or less inefficient. A general treatment, therefore, of hygienic law is necessary

as well as a course in physiology and personal hygiene. A great many men are inefficient largely because they lack a knowledge of how to take care of themselves, so that it is part of the system of scientific management to conduct a campaign of education along these lines. This, of course, cannot be done intelligently unless the men at the head of the organization realize what this means to its fullest extent.

It seems to me, in view of the fact that our engineering schools are turning out the men who become the heads of our large manufacturing concerns, that it is of the utmost importance that they send out their students thoroughly equipped with a knowledge of the principles of scientific management and in this connection I believe that the course should include visits by the students to establishments now operating under this system. This would not only tend to make the course more interesting, but would fix in a more permanent way the things learned from the text-books. In conclusion, I can say that the large progressive manufacturers of the country would welcome the thought of our engineering schools taking up this subject.

AN AUXILIARY TO COLLEGES IN THE TRAINING OF SCIENTIFIC MANAGERS.

BY ROBERT THURSTON KENT,
Editor of Industrial Engineering, New York.

The writer has always had a high opinion of the plan inaugurated by Dean Herman Schneider at the University of Cincinnati for the training of engineers, that is, the spending of a portion of the college course—which is five years in length—in the shops of Cincinnati or nearby towns, during which period in the shops the students work side by side with the regular workmen, receiving instruction and training in shop methods which it would be impossible to give them in the college shop. Although the length of the course seems excessive, the plan for the most part is an admirable one in many respects for training engineers who are to become machine shop superintendents, managers, or to hold positions of similar character in other manufacturing lines. Without doubt, the same idea could be successfully applied to other lines of engineering work, such as the various phases of civil engineering, electrical engineering, power plant practice, heating and ventilating or any one of the many specialties in which the mechanical engineer finds occupation.

While scientific management is comparatively new, yet, in a number of industries in this country its principles have been applied with uniform success. These shops, in the writer's opinion, will form the best auxiliaries to the colleges in the training of scientific managers, operating with respect to scientific management courses in the colleges, exactly as do the shops of Cincinnati to the engineering course in the University of Cincinnati. It is not necessary for the purposes of training an engineer in the principles of scientific management that he study the operation of these principles in a machine shop. The principles underlying scientific management are

the same in every industry, and the student in a management course can study their operation fully as well in a textile mill or a printing establishment, as in a machine shop. It may be that he can study them even better, for in many industries there is not the complexity of operations that obtains in machine work, which might appear to befog the clear discernment of the underlying principles.

The most powerful auxiliary to the college in the training of scientific managers, therefore, is the shop in some line of industry which is operated according to the principles laid down by Dr. Taylor. It is not to be expected that a student should become a finished textile worker, printer or machinist should he use one of these industries as an auxiliary to a management course, but he can learn in the most thorough manner in any of these industries, the principles of routing, of scheduling, of planning, of time-keeping, store-keeping, and he also can learn by acting under the instructions of one of these officials, the functions of the speed boss, the gang boss, the inspector and the disciplinarian. In the planning department, he can act, always under supervision if necessary, as instruction card man, time and cost clerk, route clerk, etc.

The plan the writer advocates in the training by colleges of men to fill positions under scientific management, is that each college having such a course arrange with one or more industries in its vicinity to have its students spend a part of their time in that industry, much along the lines that the students in the University of Cincinnati spend their time in the shops of that city. The course should be arranged so that the students will spend several consecutive days or weeks each month in the shop, performing the functions of one or more of the planning department officials or of the functional foremen out in the shop.

The writer is of the firm belief that engineering education is of comparatively little commercial value until it is supplemented by practical training in commercial work, whether that work be shop practice, construction work or any other line which the student elects to follow subsequent to the com-

pletion of his college course. This idea applies just as much to engineering work which specializes in management as it does to engineering which specializes in machine design, power plant practice or any other line of engineering. The student who has studied the theory of management from books and depends upon this theory alone is apt to encounter many pitfalls in his attempt to apply what he has learned. The big problems in management are not those of following a certain fixed set of forms or rules based on the fundamental principles enunciated by Dr. Taylor. The vital problem in management is that which involves a human element. It is psychological and until the would-be manager actually comes in contact with the workmen and comes to understand the attitude of the workmen toward all in authority above him and toward his work, he will inevitably fail in his attempt to be a successful manager. This knowledge cannot be gained in the class-room. It must be gained by actual physical contact with the workmen. It is, therefore, the writer's opinion that no college giving a course in scientific management can have a better auxiliary than a close working connection with some industry that is operating under the principles of scientific management.

EFFICIENCY IN ENGINEERING EDUCATION.

BY GEORGE H. SHEPARD,

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The principles of efficiency are definitely known. The following table compares the two most famous statements of them:

TAYLOR'S STATEMENT. The Four Elements of Scientific Management.	EMERSON'S STATEMENT. The Twelve Principles of Efficiency.
The development (by the management, not the workman) of the science of the work, with rigid rules for each motion of every man, and the perfection and standardization of all implements and working conditions.	Supernal Common Sense. Competent Guidance. Standardization of Conditions. Standardization of Operations. Determination of Standards.
The careful selection and subsequent training of the workers into first class men, and the elimination of all men who refuse or are unable to adopt the best methods.	Ideals. Discipline.
Bringing the first class workman and the science of the work together, through the constant help and watchfulness of the management, and through paying each man a large daily bonus for working fast and doing what he is told to do.	Fair Deal. Efficiency Reward. Immediate, Adequate and Reliable Records.
An almost equal division of the work and responsibility between the workman and the management. All day long the manage-	Standard Practice Instructions.

ment work almost side by side with the men, helping, encouraging, and smoothing the way for them, while in the past they stood one side, gave the men but little help, and threw onto them almost the entire responsibility as to methods, implements, speed and harmonious coöperation.

Planning and Despatching.

To resolve all efficiency into certain definite principles was a service comparable to the analysis of all matter into a limited number of chemical elements. The principles of efficiency are applicable to absolutely all human activity, and, though discovered in industry, by the aid of them, the Emerson Company has done betterment work in an institution as remote from industry as a hospital. Just as, by applying the tests for the different chemical elements, a qualitative analysis can be made of any substance, so by searching for the presence in any work of each of the principles of efficiency, a qualitative analysis of its efficiency can be made, that is, it can be determined in what respects the work is efficient and in what inefficient. In this paper I submit to the Society such a qualitative analysis of American engineering education. A sufficient reason for my using Emerson's principles is that they are to me familiar tools. A college, of course, has its business side, an enquiry into the efficiency of which has been conducted by Morris L. Cooke and reported to the Carnegie Foundation under the title of "Industrial and Academic Efficiency." This paper is confined to the educational work of the technical college. Probably many of the suggestions that I make will be considered impracticable; but it is only by the successful accomplishment of things that the so-called "practical man" thus condemns off-hand, that the science of efficiency has attained its actual measure of achievement.

I. Ideals.

The ideals of a college, at least of its faculty, are commonly known as the "college policy." I suppose that every college

faculty talks in faculty meetings about its "policy" and thinks that it has one; but that sacred thing is likely to be composed of a number of rather unrelated dictums, like "We do not accept substitutions except in kind," and "We discourage the admission of special students"; while a college policy in the sense of a clearly defined ideal, toward which, in all its activities, it is constantly, consciously, and consistently striving, is apt to be lacking.

The German technical university has a definite and clear ideal. It is to be the leader and guide of German industry in the application of science to its work. This ideal has the support of the state, the faculty, and the students. The professor is expected to be, and is, a producer of new knowledge, of which German industry receives the benefit; and this is a principal cause of German scientific and industrial eminence. Students are a by-product, of which twenty-five per cent. or more are reclaimed. Now a single correct ideal does not make efficiency, but it is a step in the right direction; and certainly the German technical university has it.

At the head of the American university is usually a board of regents or of trustees, who are not supposed to be educators and whose ideal for the technical college, if they have any, is probably best expressed in the words of the Morril Land Grant Act—"to teach such branches of learning as are related to agriculture and the mechanic arts." That means, to pass along the rudiments of technical knowledge to successive classes of undergraduates. Far from the professors being supposed to be fountains of new knowledge, they are considered to do well if they can keep their own attainments abreast of the progress of industry. For the achievement of this ideal the regents or trustees are dependent upon a faculty which is usually thoroughly permeated with the German ideal. In the usual American technical college the ultimate authority does not recognize or support the ideal of discovery of new knowledge, therefore research cannot be efficiently carried on; the faculty accepts with reluctance, as something forced upon it from above, the ideal of merely giving instruction and

strives futilely to follow its own ideal. A certain famous American physicist, after stating the researches that he expected to make during the next session of his university, was asked: "What will you do with your students?" "Neglect them," was the reply. Neglect of students does not tend to efficiency of teaching.

It behooves every American college faculty to consider seriously what the ideal of the institution really is, not what the faculty would like it to be; and, unless reform, rather than efficiency, is sought, to bend its energies to the loyal support of that ideal. On the other hand, I have before this stated to this society my belief that a college teacher cannot command the respect of his students sufficiently to secure high efficiency unless they recognize him as a first-hand authority and source of knowledge in his subject instead of a mere conduit from original sources to his students. It therefore behooves the ultimate authority of the university to accept the ideal of production of new knowledge and properly to support the pursuit of it. There can be only low efficiency where the two ideals are in conflict. There can be fair efficiency, in the pursuit of either ideal where it alone is held and is consistently followed. There can be high all-round efficiency only where both ideals are recognized and harmonized.

Another ideal that requires clear definition is whether the college is to give a broad general grounding in the fundamentals of engineering, or is to give a highly developed, but narrow, education in some specialty. The former is becoming more and more recognized as the only proper ideal of the undergraduate courses, the second being reserved for graduate specialists. In spite of this, the teachers, having necessarily developed into specialists, tend to try to develop even undergraduate students into specialists in their own lines. Also the curriculum, under the care of these same specialists gradually becomes overgrown with specialties. The professor of electrical engineering, for example, thinks that a three-hour course in wireless telegraphy is something without which no one can properly be called an electrical engineer. The senior

"electricals" are carrying only twenty-two semester hours, so of course they can take on three more. At the next faculty meeting, therefore, the professor recommends a three-hour course in "wireless." Faculty courtesy, of course, requires that the professor should have what he wants in his own department, so behold the hapless senior electricals carrying twenty-five semester hours. Meanwhile the preservation of a curriculum well balanced in the fundamentals of engineering, being everybody's business, is nobody's business.

II. Supernal Common Sense.

The efficiency principle of supernal common sense requires nothing less than the application to the work in hand of all the wisdom and knowledge that can be brought to bear upon it. It is a very grateful task to the technical professor to rub this principle into the industrial manager, who is prone to employ a cheap and uneducated draftsman to work out by empirical thumb rules from a hand-book, problems which the professor knows would be much more cheaply and efficiently done by himself, on a basis of real science, and for a large fee. This is one of the vexations of the professor's career. Let us, however, consider the technician in the act of teaching.

When, as dean of the engineering college of Syracuse University, I tried to apply the principles of efficiency to the work of that college, I found myself at once in the thick of problems of psychology and pedagogies. Considering that all teaching is an application of these two sciences, it has ever since seemed to me strange that from my first day as a young instructor I was not placed under their guidance, for it is self-evident that there can be no efficient teaching except in obedience to their laws. I was struck also by the fact that those students who had athletic ambitions were training to keep their bodies in the best possible condition, but all students, as far as conserving their brain power was concerned, were living haphazard lives. It seems plain that the man who wishes to use his brain at maximum efficiency should live under a proper regimen of diet, exercise, sleep, recreation,

and study; in other words, should train as assiduously as the athlete, and much more continuously.

Now in psychology, pedagogics, and physical training, I had precisely that little knowledge which is a dangerous thing. Moreover I had not time to master these subjects. Any technical teacher is likely to find himself in very much the same situation. Our own subjects are big enough to absorb all of our time and labor without any prospect of our ever attaining exhaustive knowledge of them. In as far as we allow ourselves to be diverted from them, our proper usefulness is diminished. The solution is to be found in the application of the next principle.

III. Competent Guidance.

The facts which I have stated in the last two paragraphs lead me to believe that every technical college should have as staff advisers an expert professional teacher, and a physician who has specialized in physical training, while efficiency itself should be under the charge of an efficiency engineer. Those members of the Society who are not familiar with staff organization are referred to Mr. Harrington Emerson's books, "Efficiency as a Basis of Operation and Wages" and "The Principles of Efficiency." In special cases still other staff officers might be necessary. I am satisfied that in any case, the three above mentioned are essential to the best efficiency. I mention here only the chiefs of staff. Each chief should, of course, have such subordinate assistance as is required by the amount of work on hand. Undoubtedly most boards of university regents or trustees would object on the ground of expense to the employment of pedagogic, medical, efficiency and other staff. It is difficult to convince even university authorities that brains are really needed in the conduct of an institution, and that, though they are costly, in the end they pay better than any other investment. It must be recognized that knowledge is the price of efficiency, and they who will not pay for the former cannot have the latter. Those of us who have the good fortune to belong to colleges which are

parts of universities, can probably appeal to the self-sacrificing spirit common to teachers, to obtain the assistance of experts from the other faculties. At Syracuse I laid my pedagogic and pyschological problems before Dean Street of the Teacher's College, and found him more than willing to advise me. If, by similar means, an actual demonstration of improved efficiency can be made, a basis will be secured on which to appeal to higher authorities for financial support.

Another difficulty which will have to be met is unwillingness to accept staff assistance. Some teachers will doubtless feel affronted by the suggestion that their work should be inspected, and that they should be advised by a pedagogic staff. Probably very few students will at first accept the idea that they should go into training for their scholastic work. These difficulties are to be overcome, precisely as the objection of industrial workers to staff guidance is overcome. A selected few are first to be found who appreciate and willingly accept staff guidance. The efforts of the staff are at first to be concentrated on these, and upon them a demonstration is to be made that they profit by those efforts. The benefits received by them will make others more willing to accept the same advantages, and the work can gradually be extended.

Dealing, as we do, with immature youths, the proctor system of the English universities would be a valuable addition to our staff. The function of the proctor is to keep in close touch with a group of students assigned to him and to advise them both as to college and outside affairs. All of us know that our students, notably the freshmen, would benefit greatly by close touch with a wise and friendly adviser. The technical faculties are too heavily burdened for them to assume this function. I wish it to be clearly understood that I do not anywhere in this paper advocate adding to the labors of the present teachers. On the contrary they should be relieved. In supervising students by proctors, it is necessary to remember that too close keeping of an adolescent in leading strings is fatal to his development, a fact which nature has recognized by giving him a strong instinct to rebel against it.

At the same tme, he is not yet fit for complete self-guidance. The situation is critical and calls for careful selection of the proctors and for their classification as junior officers of the psychological staff. If, in conjunction with betterment work in the institution itself, courses in efficiency could be given therein for which credit would be given, selected upper class men who were taking the efficiency course could be made proctors over the freshmen as part of its work. I mention this only as a temporary expedient, recognizing that betterment work in a university must prove itself before financial support can be got for it. As soon as possible the proctors, or tutors, should be regular salaried officers of the university administration. They will doubtless pay for themselves. In an institution where the students pay tuition, a proctor would not have to save many from the various pitfalls which drop the unwary from the rolls, in order to earn his salary. In state universities the economy would return to the public indirectly, but really, by saving students from failure, by guiding them into careers for which they were suited, and by enabling them to graduate with sounder bodies and better minds and characters.

IV. Discipline.

In the matter of discipline, the American institution of learning has a tremendous advantage. Those who are accustomed to think of discipline only in terms of the man-of-war would probably, on a superficial examination, be impressed that there is no discipline in the college; but that is far from the fact. With all their free and easy ways, college students are obedient; and they usually regard their teachers with respect, and often with affection. Moreover, they are filled with an overflowing love for, and loyalty to, their Alma Mater, which, though sometimes mistaken in its expression, is very real and offers an unfailing appeal to them on behalf of all right action. It would be to any industrial organization an asset of untold value to have among its employees an espirt de corps at all approaching "college spirit."

With local variations, there is, in the main, only one direction, in which improvement in discipline suggests itself to me. That is in the more careful selection of young men for the engineering profession. I am not speaking here of the educational requirements for admission. To all of us cases are familiar of students, struggling along in the technical colleges, who are totally unfit to be engineers. I remember one young man who turned in a design of a boiler, with the mouth of the furnace blanked off by a solid steel plate, and who afterward found a more congenial career on the stage. Of course the "bust-notice" usually gets rid of most of these, but there are many who have too much brains for that, who drag along to their own unhappiness and the despair of the faculty, and to ultimate failure in life, unless they go into some other work before they are too old. It should be one of the functions of the proctors to find such cases very early in their student careers, and to bring them to the attention of the faculty. The latter should advise, and should have authority, advice failing, to drop from the student rolls for unfitness for the engineering profession.

V. The Fair Deal.

Under the head of the fair deal we can gladly mark the technical college 100 per cent. (minus) and let it go at that. While the college has not attained absolute perfection, that industry is indeed a shining light, in which the workers have as much confidence as prevails in a college in the justice of the administration. Such confidence is a great advantage in undertaking betterment work. For example, the dropping of students for unfitness for the engineering profession, advocated above, could not be undertaken by any faculty in whose fair dealing the students did not have confidence.

VI. Standardization of Conditions.

The purpose of standardization of conditions is not only to make conditions constant, or standard, but to make them as

suitable as possible to the work in hand. The idea of adaptation is quite as prominent as that of standardization. Adaptation, of course, works both ways. Adaptation of conditions to the work is most desirable, but is often impossible. Man has been obliged, in the main, to adapt his work to his conditions; that is, to do what his circumstances allowed. Far be it from me to decry a noble effort to do needed work under adverse circumstances. Humanity owes its progress to the fact that heroes, saints, and martyrs have sacrificed even their lives in such attempts, but that is aside from efficiency, which is the subject of the present paper.

Under the head of adaptation, or standardization of conditions, there is more need of a propaganda among the financial authorities of colleges than among the members of this society, who like other college professors, are undoubtedly as insistent on proper equipment for their departments as they can be without becoming completely disliked in the president's office. Among the financial authorities, equipment is often a case of cutting the coat to fit the cloth; but, when a university puts a half million dollars into a gigantic stadium and another quarter million into a gymnasium, while its engineering college is turned off with a niggardly equipment, it is plain that its administration is inappreciative of the application of this principle of efficiency in technical education.

It is also obvious that a college should not undertake work for which, by location or otherwise, it is manifestly unsuited. One cannot think, for example, that a school of marine engineering is likely to be highly efficient in an inland college remote from any more striking example of naval architecture than a canal boat. If we had had pedagogic guidance, we should long ago have recognized the superiority of the practical-theoretical method of teaching, which is followed only by the few institutions that have adopted the coöperative, or part time, plan over the theoretical-practical plan which is still followed by most. If we had designed a man on the drawing board and then built him in the shop, we should probably have made him so that he would have inquired first

Why? and then What? and then How?. He would have been a highly intelligent creature whose career would have come to an end the first time he was confronted by an unknown and unanalyzed danger. Imagine him in the path of a speeding automobile. It would be time to telephone for the undertaker, before he had satisfied his philosophic mind that there was sufficient reason for a quick dash to safety. Man, being the product of a long struggle against adverse conditions, has been so firmly impressed by heredity with the necessity for quickly deciding How, and of the inadvisability of bothering with What and Why, unless the thing later seems worth while, that his mind will work that way, even when, on the whole, it would be rather better if he reversed the process. Much as we may deplore his perversity, we shall succeed best by operating him in his natural direction of working.

Hence we shall teach best, if, instead of pouring academic knowledge into our students for four years, and then turning them loose to find, on their own resources, its relation to practical industry, which seems strangely indifferent to their learning, we bring them, before and during their college courses, into actual working contact with industry and coördinate their academic instruction as closely as possible with their practical experience. This is a standardization of conditions which, by coöperation with industry, is within the reach of all.

VII. Determination of Standards.

For the sake of brevity, I shall discuss under this head only one standard which the technical college conspicuously lacks. That is one of student capacity. How much work of any given subject can a student reasonably be expected to do in an hour? How many of us are there who can answer such a question, even with reference to our own subjects only, on any basis of real knowledge? The most of us probably know only that as students, we ourselves succeeded in learning about so much per lesson. How much time had we per lesson? How much time has the student now? How many of us know, not guess, the answers to these questions? In the face of these

uncertainties, the inevitable tendency of the specialist, who realizes much better the infinite ramifications of his own subject than he does its relative unimportance in the general scheme of things, is to pile onto his students always a little more and a little more, until the task becomes an impossibility. The result is inevitable. On the one hand the student must resort to cramming, to memorizing, to bluffing, in order to get through. On the other hand the teacher, for the sake of his own reputation, must not appear to be unable to communicate his knowledge to a reasonable proportion of his students, the only tangible evidence of which knowledge is a passing mark reported to the registrar. Hence a continual loading of the subject is bound to result in a continual decrease of thoroughness on the part of the student, and a continual lowering of scholastic standards on the part of the teacher. I was once one of the assistants of a very eminent engineer, who had the habit of handing out to us more work for a day than we could do in a week. Fortunately one of us soon discovered that he forgot the tasks, as soon as he had assigned them, and kindly gave the rest of us the tip. Thereafter, I received orders for the most preposterous tasks without either a protest or a smile, did what I could and forgot the rest, which my chief also very kindly did. The results, between the overloaded student and the specialist professor, are bound to be similar.

There is need here for some time study work of the very highest grade. The idea of time study of mental work may strike some as impracticable; but Dr. F. W. Taylor wrote me that the first time studies of which he ever knew, and which first suggested the idea to him, were made by Professor Wentworth on work in algebra, when Taylor was one of his students, and that Wentworth based his assignments of lessons on these studies. As soon as it has been determined what the students can reasonably be expected to do, that much should be assigned to them and no more, and they should then be absolutely required to do it. The result can not fail to be a great improvement in thoroughness; and, while the diploma

may not certify that graduates know so much, it will mean that they really know a great deal more, beside which the moral training of always fairly and squarely meeting a reasonable requirement, will be of inestimable value.

VIII. Standardization of Operations.

I have been told that Gantt classifies the human race into routine workers and experts. There is something like that in his book, "Work, Wages, and Profits," but I cannot say where I got it in precisely that form. This is by way of apology to Mr. Gantt, if I have misquoted him. Anyhow, the routine worker can do only what he is told, as he is told to do it, following over and over a beaten path, until he attains speed and skill as habits. The expert is constantly confronting new conditions, under which, by the application of invariable principles, he works out methods in infinite detail to meet each particular case.

The betterment man is accustomed, in industry, to blaze the trail for routine workers. In the technical college he is to improve the education of embryo experts, who are themselves to become pioneers. It would be fatal to their development to make them work according to hard and fast rules such as are set before the routine workman. On the contrary, problems must be set before them which they must be left to solve as nearly on their own resources as possible. Only by so doing can they attain the necessary independence and self-reliance. The industrial operation is standardized in order that the routine worker may do it in the most efficient way. It is vastly less important that the student should do his work in the best way than that he should do it himself. An excellent paper along this line was contributed to the American Society of Mechanical Engineers some five years ago by Dr. Lucke, under the title of "The Function of Laboratory Courses." After myself experiencing conviction of sin as a result of that paper, I entirely withdrew from my senior laboratory students all written instructions for their work

and required them to work out their own solutions of laboratory problems. Nevertheless this led to a standardization of the operation of such solution along the following lines:

1. The assignment of a problem; for example, to determine the thermal efficiency of some engine over its complete range of load;

2. A preliminary lecture, giving only so much explanation as was absolutely necessary;

3. The division of the students assigned to a problem into certain standard committees,

The Foreman, and Committee on Stations and Duties for Experimental Work,
Committee on Apparatus,
Committee on Runs and Logs,
Committee on Final Report, and
Committee on Prediction of Result;

4. The rotation during the year, of each student through all the committees, so that he gained an experience of all phases of laboratory work;

5. The preparation by each committee of a report on its part of the problem, comprising definite instructions for the conduct of the further work;

6. A seminar in which each committee presented its report, which formed the basis of action by the whole squad;

7. A preliminary report on the problem from the whole squad;

8. The performance of the experimental work under direction of the foreman, in accord with the preliminary report;

9. The calculation of results by the whole squad under direction of the foreman; and

10. The submission of a final report by the whole squad.

The above is submitted as a concrete example of the fact that it is possible to standardize operations and at the same time to put upon the student the responsibility of solving his problems for himself. It would be an impertinence for me to offer to my fellow members any further suggestions as to

the standardization of their own operations. As to the student, many of his operations might be standardized with improvement in his efficiency, and without decrease of his independence. For example, it was not until my own fourth year in college that I learned how to study a technical text. Until that time, when the author said, "It is obvious that," I immediately set to work to dig out for myself the conclusion, which in most cases was very far from obvious to me. I finally found that the author usually gave his reasoning on the next page, a discovery that has saved me many a weary hour since. Doubtless it developed my cerebral tissue to think for myself the thoughts of Cotterill, Remsen, Thurston, and their peers; but, for a college boy, the task was almost too much, as some narrow escapes from being sent home painfully impressed upon me. Probably others have failed from similar causes, who might have been saved to professional careers merely by standardization of the operation of preparing a lesson.

IX. Standard Practice Instructions.

I have often had occasion to advise a student to take a tutor, not to teach him the subject, but to show him how to study it. At present such occasions come to a college teacher in a haphazard way. If he is interested in his students and enquires into the troubles of any of them who are not getting along, or if he is the man to attract their voluntary confidence, he is likely to have such opportunities. If he is absorbed in his subject to the exclusion of human interests, he may not care or even know how his students are getting on. In this country we are apt to condemn a man of the latter type, but he is more apt than the other to know his subject, and no man can teach what he does not know himself. To know exhaustively a subject in up-to-date engineering is one man's job, and the only way to enable him to do it at high efficiency is to relieve him of distractions in other directions. The college teacher's business should be his subject, and the responsi-

bility for student welfare should be in the hands of a separate corps of workers; while the head of the college should be relieved of the details of both kinds of work, but should be a man broad enough and big enough to dominate both classes of workers and to control and coördinate their work.

The proctors should find out, as a matter of regular duty, instead of leaving it to the teachers to find out by chance, whether any young man is working inefficiently; and, if he needs standard practice instructions, they should have the means, by conferences with the pedagogic, psychological, and medical staff, and by reports to the head of the college of needed action, to make sure of his getting them.

Standard practice instructions along other lines, for example the notation of drawings, may with advantage be provided, and commonly are; but these are matters of detail, which vary with local conditions, and do not admit of general discussion.

X. Planning and Despatching.

In the application of the efficiency principle of planning and despatching the technical college is far ahead of most

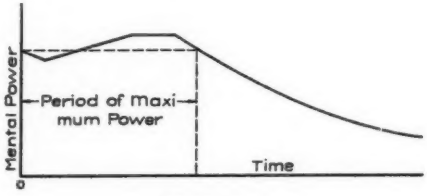

Fig. 1.

industries. The curriculum as a whole is planned from the outset, subjects are arranged in logical sequence, and the time allotted to each is predetermined. Classes are despatched as to hours and rooms, a year in advance. If, however, we examine the basis of scientific knowledge for our elaborate planning and despatching, the bubble of our satisfaction is imme-

diately pricked. For example, why is the standard period for a recitation or lecture one hour? I have been unable to find any better reason for it than that the hour is a clock unit.

Now it is known that in mental work, the relation between time and power is somewhat as shown in Fig. 1. First there is a period of decreasing power, similar to the "warming up" in athletics; then a period of increasing power; then one of nearly constant power, a maximum plateau; and then fatigue sets in with continually decreasing power until complete exhaustion is reached. Also it is known that, in the early stages of fatigue, rest brings quick recuperation; while, after exhaustion is approximated, recovery is slow and rest must be long. If every one had the same curve of time-power, it would be easy enough to find the time of maximum power ordinate; but there are great individual differences. In some cases the time of warming up is inappreciable; in others it is very long. Some individual curves show an absence of the maximum plateau. With these individual differences, is it feasible to find a composite curve of which the period of maximum power will approximate the general average? Or, if not, is it feasible, in drafting room and similar work, for individuals to recognize their own periods of maximum power, and to work accordingly? The composite period of maximum power being determined, how many such periods per day will produce the maximum efficiency? What should be the interval between such periods? Perhaps the psychologists know the answers to these questions. My own transfer to betterment work in industry has made other matters so much more pressing that, for myself, I have been obliged to retire them from present consideration. As far as I know, the psychological, pedagogic, and medical staff have a good piece of work cut out for them to find the answers. Probably original research will be needed; but efficiency engineers would not get far, if they were daunted by such a necessity.

When we know how long a student ought to work at one time, when we know how many hours he ought to work in a day, and how many days in a year, we shall be able intelli-

gently to determine the number of semester-hours he ought to carry. When we have time standards for the students' work, we shall know how many semester-hours should be assigned to each subject. Let us not be scared by the number of such standards required. A certain large industrial company has sixty thousand such. When we know student capacity and have time standards for each subject, we shall be able to build up a curriculum with scientific accuracy instead of by rule of thumb. If the result should be an increase of the number of years of the course, I should regret it; but, if it is necessary to pay that price to secure efficiency during the engineer's working years, it must be paid. I expect that general betterment, in education as in industry, will so greatly increase working capacity that there will be no such necessity. Connected with any effort to establish time standards for subjects, there is bound to be a vigorous pruning, an analysis of subjects into their fundamental principles, and a concentration of effort on instruction in these and in practice work in their application, together with the cutting out of all dead wood, and, in undergraduate courses at least, of refinements which are of interest only to the specialist. Such an elimination of waste labor will in itself very highly conduce to academic efficiency.

Coming to detail despatching, many students are in great need of its application to them individually. Some years ago a senior came to me and complained that he did not have time to do his work. I said to him "Getting your work into your time is a good deal like getting your clothes into your trunk. If you stand across the room and throw things at the trunk, just as you happen to find them, you have to get several fellows to sit on the lid; but, if you fold things neatly and stow them in orderly fashion, you probably have the top tray empty. Sit down and let us make out your weekly schedule." The schedule being made out accordingly, showed no work from one o'clock Saturday afternoon until eight o'clock Monday morning, whereupon I filled in for Saturday afternoon "Physical exercise in the open air." This young man had a

very particular chum in the coeducational department; and nearly every Saturday afternoon for the rest of his course, I met him walking with her, whereupon he used to hail me with, "You see, professor, I am sticking faithfully to my schedule." An efficient staff of proctors would have got hold of this young man in his first week in college, and the course of true love might have run smoothly, not only through the senior, but the junior and sophomore, and perhaps even through the freshman year, and that without neglect of lessons, by virtue of running on schedule time.

XI. Immediate, Adequate and Reliable Records.

The technical college has an abundance of educational records which in the main are immediate, adequate, and reliable from the point of view of the faculty, and adequate and reliable, but not immediate enough, from the point of view of the student. Their reliability may seem questionable, seeing that the marks which a student receives, represent merely a teacher's general estimate of the value of his work; but experienced markers, working independently, will grade the same within a few per cent., if they have time enough to work with reasonable care, so that, unless the faculty is obliged by overwork to mark hastily, the records ought to be substantially reliable. It is my own belief that a student ought to know all of his marks very promptly. Yet I have known a worthy professor to move, and his faculty to pass a resolution, forbidding teachers to acquaint the students with any marks; and, unquestionably many teachers prefer not to tell what marks they give. I could never bring myself to much patience with this attitude. It always seemed to me like mere shirking. If a teacher gives a mark, he ought to be able to justify it by good reasons; and those teachers who willingly tell their marks are not bothered by unreasonable complaints from students, nor do they give cause for reasonable complaints.

At my own Alma Mater it was the custom to post on each class bulletin board at the end of each week the names and

marks of all students whose average for the week was unsatisfactory in any subject; and, one month before the end of each semester, the names of all students who were in danger of failure at the end of the semester. Such timely warnings doubtless prevented many failures; and, except that notice of deficiency might better be privately given, the customs are certainly worthy of imitation. Not only the student concerned but his proctor should be informed at once when he begins to receive failing grades and the proctor should at once investigate and start remedial measures.

XII. Efficiency Reward.

The principle of efficiency reward must be considered with reference to students and faculty. The student has a form of nominal efficiency reward in the marks which he receives; but, unfortunately, there are not many students to whom one passing mark is any better than another. In fact some students regard any surplus of mark above barely passing as a waste of effort and an indication of personal inefficiency. On the other hand, athletics offer, in bodily vigor, excitement, applause, admiration, and the coveted block letter, an immediate and highly prized efficiency reward. Social affairs and student politics offer also excitement, applause, admiration, some power, and very enticing pleasure. In contrast the rewards of scholarship seem few and empty. It is no wonder that so many students are diverted from the supposed main purpose of the college.

By way of increasing the rewards of scholarship in ways that make an immediate appeal to the student, such societies as Tau Beta Pi and Sigma Xi, are of undoubted value. Their usefulness will be increased by such marks of distinction as the institution can bestow on the local chapters. The main solution of the difficulty is to impress upon the student that knowledge is the thing of value, and that, if he gets that, marks and even diplomas and degrees are negligible quantities.

While various means to this end at once suggest themselves, it seems to me that the most powerful is to give the student

an object lesson in the need of scientific technical knowledge, to make him feel his lack of it, by bringing him from the outset of, and throughout his college course into close practical contact with industry by means of the coöperative, or part time, method of instruction. Any one who doubts this has only to compare those of his own students who have had practical experience with those who have not. While the former, from necessity of spending much of their time and energies in self-support, may be only fair, or even inferior scholars, they do not fail from lack of interest in their work. Once the student realizes that knowledge is what he is after, and not marks and degrees, his efficiency reward becomes immediate, automatic, and unfailingly just.

Turning to the faculty, there are four ways in which efficiency should be rewarded: (1) by salary, (2) by social standing, (3) by promotion, and (4) by opportunity.

As to salary, including under this head old age, and service pensions, the subject has been worn threadbare, and there is no profit in discussing it in any length in this paper. The mere fact that the best men are being continually drawn away from teaching into industry and that our ablest engineers are to be found in practice and not in professorships, as in Germany, is proof enough that the reward of our teachers is inadequate. When any institution undertakes betterments, one of the first uses that must be made of financial economies resulting from greater efficiency of the material side of the institution, from immediate, adequate and reliable cost-keeping, from using costly steam heat to warm buildings in use instead of to kill the campus grass, and from efficient use of buildings and equipment now idle a large part of the time, is to increase the compensation of its teachers.

As to social standing, the situation is not bad; but such distinguished consideration as attaches to a university professorship in Germany, would, of course, hold many men to the teaching career in this country in spite of more lucrative opportunities in practice.

As to promotion, efficiency reward is here directly opposed

to the commonly accepted ideal. The very university president who fails utterly to support research by his faculty, who looks upon it in fact rather as a diversion from their proper work of teaching, will, if he has an important position to fill, seek a man "whose name will strengthen the institution." That means inevitably a man who has been in some way a discoverer of knowledge, because mere teaching and administration, no matter how faithfully and well done, make one known only to his own students. If the ideal is to continue to be merely "to teach such branches of learning as are related to Agriculture and the Mechanic Arts," in order to attain efficiency in its pursuit, efficiency reward must be based upon it; and, when promotion is possible, it must be bestowed upon the efficient teacher. If, without sacrificing our own ideal, we are to adopt in addition, as we should, the German ideal of leading and guiding industry in the application of science to its work, the ultimate financial authorities of our institutions, and finally society itself, which in the end must bear the burden of all education, must learn to support both teaching and research, and appropriately to reward efficiency in both.

As to opportunity, a motive which, to a man of the right type for a college teacher, is quite as compelling as the desire for financial reward or for academic or social position, is the ambition for honorable fame as one who has rendered distinguished service. To the college teacher the means which at once suggests itself to that end is research. The substantial denial of such an opportunity in our technical colleges, removes from them one great and highly prized efficiency reward. I count among my most valued friends one of our most distinguished practicing engineers, a man of surpassing character and of wonderful devotion to altruistic service. Some years ago he was one of our most distinguished technical teachers, in an institution ranked by all as among the best, and by many as the best in this country. Shortly after his leaving teaching for practice, I said to him that I should have thought that he would have stayed in teaching in order to

develop his ideas by research and invention. He replied: "I saw that there was no chance for me to do anything of that kind there."

XIII. Financial Results.

It may be objected that the proposals above all tend to greater, not less expense. This is the stock objection of the unconverted captain of industry to all suggestions of greater efficiency. Inevitably betterment work increases the ratio of indirect to direct expense; but experience in industry has fully shown that it increases even more the ratio of production to total cost, so that the final result is a decrease of unit cost. Similarly in education; by causing institution, teachers and students to coöperate in the pursuit of the same adequate and correct ideals; by applying to teaching its own sciences; by placing the workers under competent guidance; by the more thorough elimination of the unfit through discipline; by fair dealing with all concerned; by standard practice instructions for the performance of standardized operations; by the extension of the present system of schedules of classes into one of schedules for individuals as well; by the basing of all planning upon scientifically determined standards of capacity under standardized conditions; by making records immediate as well as adequate and reliable; by rewarding the efficiency of teachers, and by causing students to appreciate the efficiency reward which they have; the result is bound to be an increase of working capacity of both teachers and pupils: and this, in the end, is bound to reduce cost per unit of product.